PRE-WISCONSIN DRIFT IN THE FINGER LAKE REGION OF NEW YORK

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INTRODUCTION

With old drift on Long Island,[1] in New Jersey,[2] and in northwestern Pennsylvania,[3] it is very likely that a line of old drift should connect these areas. If, however, these localities of old drift represent ice-work from separate dispersion centers, then the re-entrant

[1] J. B. Woodworth, *New York State Museum Bulletin 48* (1901), pp. 618–70; M. L. Fuller, *American Geologist*, Vol. XXXII (1903), pp. 308–12; A. C. Veatch, *Journal of Geology*, Vol. XI (1903), pp. 762–76.

[2] R. D. Salisbury, Geological Survey of New Jersey, *Annual Report for 1893*, pp. 73, etc.; Vol. V (1902), pp. 187–89; 751–82.

[3] F. Leverett, *Monograph XLI*, U. S. Geological Survey (1902), p. 228; L. H. Woolsey, *Beaver Folio*, No. 134 (Pennsylvania), U. S. Geological Survey (1905), p. 7.

angle not covered by this drift might include much of New York state; but this supposition is hardly in harmony with accepted facts concerning the centers of ice-dispersion. Theoretical consideration, therefore, leads to the conclusion that in the Finger Lake region of New York the late Wisconsin drift sheet covers at least the ice-erosion remnants of older drift. Students of glacial geology have already tentatively presumed earlier glaciation in this region.[1]

That there has not already been reported some observed evidence of pre-Wisconsin drift in the Finger Lake region is doubtless due to one of two causes: workers may have felt that such drift should be highly weathered; or that at this distance north of the ice-margin erosion was so vigorous as to have removed the earlier drift. In all probability ice-erosion has removed most of the weathered horizon of the old drift, mingling it so thoroughly with fresh débris that it is not easily identified. In walking over the fields of the lake country one notes the presence of small bowlders which are very much weathered, bowlders that remind him of the general condition of stones in the areas of old drift; this is the most pertinent suggestion of the earlier glaciation of this region.

PRE-WISCONSIN DRIFT IN GENERAL

The older drift sheets have been studied more thoroughly in the Mississippi basin than elsewhere; their chronological sequence is generally established on the degree of weathering exhibited. In the case of the Sub-Aftonian[2] and the Iowan,[3] the lithological content is made a discriminating feature; the absence of water-laid material is a feature usually emphasized in describing the Kansan drift,[4] whereas the blue or blue-gray color of the unweathered Illinoian is pointed out.[5] Where the formations of different sheets of drift are superposed, the distinctions may be more accurately recorded; but good sections of this imbrication are rare. Some contact sections, all from

[1] R. S. Tarr, *Journal of Geology*, Vol. XIV (1906), pp. 18, 19; *Bulletin of the Geological Society of America*, Vol. XVI (1905), p. 217; H. L. Fairchild, *ibid.*, p. 66.

[2] W. J. McGee, U. S. Geological Survey, *Eleventh Annual Report* (1891), p. 497.

[3] Chamberlin and Salisbury, *Geology*, Vol. III (1906), p. 384.

[4] *Ibid.*, p. 389.

[5] F. Leverett, *Monograph XXXVIII*, U. S. Geological Survey (1899), p. 28; *Monograph XLI* (1902), p. 272.

the Mississippi valley, are shown in Chamberlin and Salisbury, *Geology*, Vol. III, pp. 385–88.

Descriptions of old drift in western Pennsylvania and in New Jersey are perhaps more pertinent to the New York area. The old deposits in Pennsylvania, described by Leverett, are very stony, the pebbles usually showing water action; the bowlders are small and mostly of local origin; only a small amount of clay is present; there is

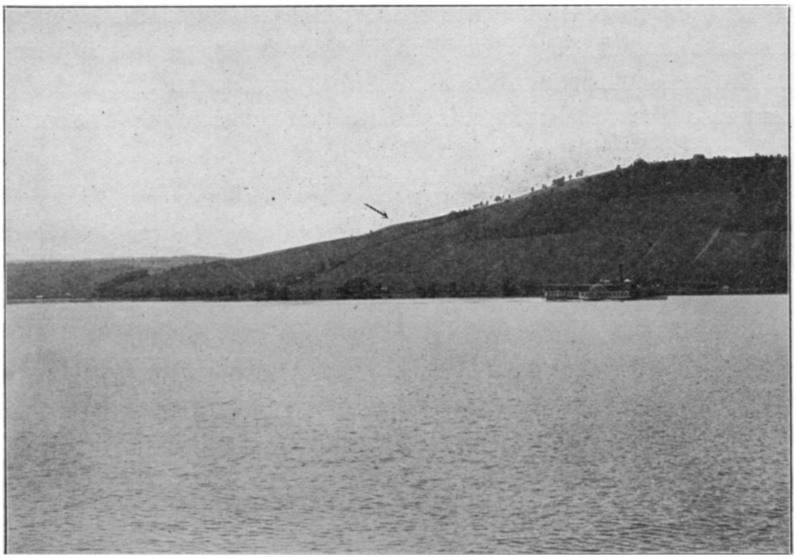

FIG. 1.—Southern portion of Bluff Point viewed from the east. The break or terrace in the frontal slope is a cusp which apparently correlates with Fairchild's Wayne overflow stage of glacial lake Hammondsport.

slight evidence of bedding; the highly weathered condition of the drift, and the great amount of erosion it has suffered, are its conspicuous characteristics.[1]

The earlier drift in New Jersey is thus described: "The outer and older drift is deeply weathered from top to bottom, even where it has a thickness of thirty feet, the greatest thickness it is known to possess. Its stones, so far as they are of decomposable rock, are decayed.

[1] *Loc. cit.*, pp. 228, 229, 235.

From it most of the calcareous matter has been leached."[1] "The constitution of the drift is, in a general way, comparable to that of the younger drift. It contains materials of all grades, from huge bowlders to fine clay." "Limestone is rarely present. When the drift occurs in quantity, glaciated stones are by no means rare."[2] "It generally lacks all indication of structure, though foliation is to be seen in some of the deeper exposures." "In its constitution, and in the relations of its constituents, the drift corresponds with till."[3]

It should be noted, however, that Salisbury does not find the extra-morainic drift in New Jersey uniform in the stage of weathering attained;[4] for this reason he suggests that, while most of it probably corresponds to the Kansan, it is possible that a younger pre-Wisconsin drift may be represented.[5]

Geographical factor.—The above descriptions of drifts pertain to deposits more or less distant from central New York. The diversity in the stratigraphy and topography of northern North America introduces other considerations that may render these descriptions only partly applicable to other regions. Similarity of glacial deposits elsewhere may result only from identity (*a*) in the stratigraphical terranes which furnished the débris; (*b*) in the period and conditions of weathering to which the débris was later exposed; (*c*) in the successions of ice-invasions; and (*d*) in the distance of the sections being compared from the termination of the particular sheet in question. It is evident, therefore, that in New England, New York, Pennsylvania, and New Jersey specific drift-sheets may have somewhat different features than have been reported by investigators elsewhere.

TOPOGRAPHIC CONTROL OF THE EROSION AND DEPOSITION OF DRIFT

In general.—It is probable that the main dissection lines of the Finger Lake area even before the earliest glaciation were north-south valleys; the troughs of the present lakes, their tributaries, primary, secondary, and lesser, had developed a variety of transverse valleys. So in whatever direction the ice-mass moved there must have been localities, of rather limited extent, where ice-erosion was less active;

[1] R. D. Salisbury, *Glacial Geology*, Geological Survey of New Jersey, Vol. V (1902), p. 174.

[2] *Ibid.*, p. 188. [3] *Ibid.*, p. 757. [4] *Ibid.*, p. 769. [5] *Ibid.*, p. 782.

also localities where the deposition of ice-débris was more pronounced. The combined effects of glacial erosion by the different invasions has not removed all the residual soil, the regolith of preglacial weathering.[1] Nor would a succeeding ice-sheet carry off all the drift deposited by a preceding invasion. Therefore it remains to inquire into the conditions most favorable to the deposition, and least favorable to the ice-erosion of former drift-sheets.

FIG. 2.—An east-west section showing contact of the two drifts as exposed south of Dunning's Landing. The wavy, irregular line marks the upper surface of the blue till.

Deposition of drift.—Aside from the ground moraine, the thickness and irregularity of which attest the heterogeneously distributed load which is being carried by the retreating ice, the localized deposits of débris represent in the first place a reaction of climatic factors that cannot be specifically determined; and, in the second place, the

[1] H. L. Fairchild, *Bulletin of the Geological Society of America*, Vol. XVI (1905), pp. 53–55; R. S. Tarr, *American Geologist*, Vol. XXXIII (1904), p. 287, and F. Carney. The writer's unpublished notes on the Moravia (N. Y.) quadrangle afford further proof of the presence of preglacial weathered products in place.

influence of topography upon the detailed outline of the ice-front. Climatic control evidently occasioned the pulsations of halt and retreat marked by the irregularly spaced belts of thickened drift; while the distribution of drift within the belts themselves is due both to local topography and to the topography of the areas passed over, in so far as these areas have contributed to the load of the ice. Furthermore, the broader outlines of these irregularly spaced belts reflect the reaction of the larger topographic features and the general direction of ice-movement from the dispersion centers; in consequence of this we have the moraines of ice-lobes. It follows, then, that no satisfactory control can at present be announced for the spacing of these belts.

Nevertheless, the influence of topography upon the detailed expression of the drift within the belt admits of closer definition. We would refer particularly to the following three conditions: (1) In a uniformly level area the ice-front would be without pronounced re-entrant angles; the drift would have a correspondingly even front, while it might have a very irregular surface. This type of topography is apt also to impose its characteristics upon the drift itself, as may be seen in the prairie regions. (2) In a section where the major valleys approach a position transverse to the general direction of ice-movement, the drift is found massed in these valleys, especially on their iceward sides; while in the tributaries of these major valleys are moraine loops or dams. (3) If, however, the chief valleys approach a position parallel to the general direction of ice-movement, we find in them lateral moraines[1] blending into loops of drift in the bottoms of the valleys; while the secondary valleys may be partially clogged or buried with drift.

Erosion of drift.—With this distribution of drift there must have been differential erosional effects produced by a second invasion of ice. Rather slight modifications would be effected under condition (1). The work of another ice-sheet passing over such an area is compressive quite as much as erosive; the more evenly the original drift is distributed, the less obstruction it offers to the progress of later ice; whereas the weight of the overriding ice tends to compact this drift.

[1] R. S. Tarr, *Bulletin of the Geological Society of America*, Vol. XVI, pp. 218, 219.

During the interval of deglaciation, stream-channeling, in the featureless topography of condition (1), proceeded slowly, since, to some extent at least, the streams were consequent. But with a larger lapse of time between the periods of glaciation this surface may have attained the relief of mature dissection, when it would present to the ice of the next invasion an opportunity for more effective corrasive work.

Each succeeding invasion would remove less of the previously

FIG. 3.—Contact of the two drifts at Crosby. The broken line marks the upper surface of the compact blue till.

deposited drift; it seems very probable that the resultant of several glacial invasions of such featureless topography is somewhat aggradational. And the final form given this drift depends upon the width and spacing of the moraine belts, if the ice were subject to varying relations of feeding and melting; or upon the thickness of drift deposited in an extensive sheet in case the feeding and melting factors were about balanced, the melting being slightly the stronger of the two.

That the resulting forms due to the aggradational action of an ice-sheet overriding these two types of drift arrangement would not be identical seems reasonable.

The drift as described under condition (2) would suffer much less from a second invasion. The deposits in the major valleys—i. e., the valleys transverse to the direction in which the ice is moving—would be somewhat protected from erosion; the weight of the overriding ice would tend to indurate this drift. But the drift in valleys tributary to these, since they trend more in unison with the moving ice, must suffer much more from erosion. When such accumulations are rather thick, it is probable that a drumlinoid form is the resultant of degradation by a second invasion of ice, particularly in these tributary valleys.

The most marked erosional effects, however, are observed in the old drift as distributed under condition (3). These valleys accord with the direction of ice-movement; if they open toward the approaching ice, greater obstruction is offered to its progress, hence greater erosion results; if they lead away from the feeding ice, the disturbance of the adjacent material may not be so marked. In the former case—i. e., the northward flaring valleys—the older drift, if not eroded, is apt to be deeply buried because of the intense aggradational work of the valley lobes which characterized the margin of the waning ice-sheet. In the latter case the ice-erosion is less effective; the augmented ice-front drainage has degraded, shifted, or covered with later outwash the earlier deposits. The application of this principle probably varies inversely with the size or width of the valleys.

But the old drift in the minor valleys of condition (3) has suffered less from ice-erosion. The stage of development of these minor valleys, and their degree of transverseness to the moving ice, are important factors in controlling the extent of ice-erosion in them.

Furthermore, under all these conditions we should find more old drift preserved in areas where during either pre- or inter-glacial time the drainage has suffered rejuvenation. The chances of such old drift being later revealed is greater in the transverse drainage lines of condition (3).

INHERENT CHARACTERISTICS OF OLD DRIFT THUS PRESERVED

Compactness.—The obvious resistance which this old drift offers to stream- or wave-cutting is its most characteristic feature. The pressure of the overriding ice-sheet has not only rendered such drift very compact, but there should be seen, particularly where the original deposits were fine in texture, a foliation due to the pressure. Lamination also might be contemporaneous with the formation of the

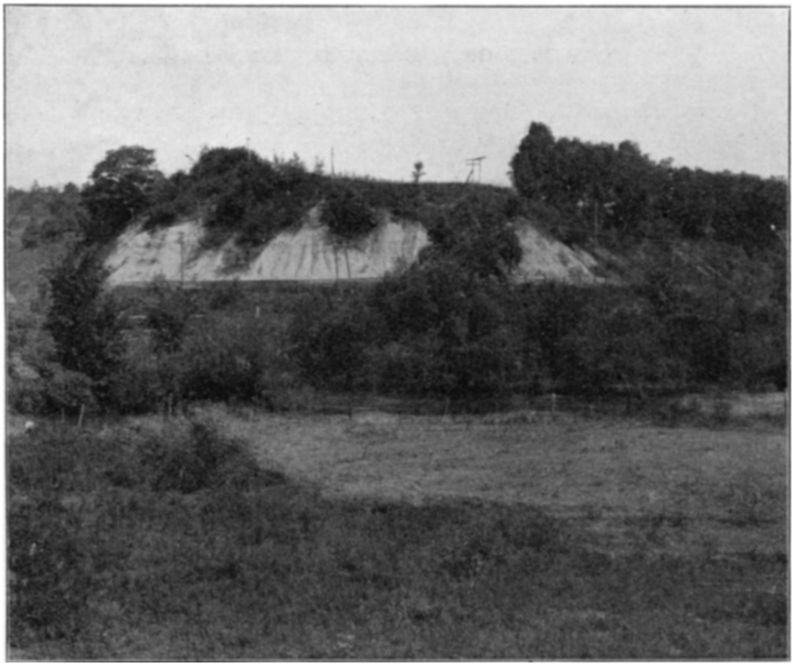

FIG. 4.—The horizon of the Wisconsin drift is fairly well defined by the vegetation; the steep bare slope consists of very compact bluish till.

deposits, but in any event it would be induced by great pressure. The effect of the superincumbent weight of a second ice-sheet should be noted, where the drift has been dissected into rather vertical cliffs, in the tendency of the pebbles and bowlders to overhang.

Color.—In the region under discussion ice-erosion has had, in general, favorable conditions for effectiveness. The highly weathered zone of an earlier drift-sheet would be most disturbed or eroded by

another invasion of ice, except in the case where ice-erosion had fallen short of the unweathered zone. The part of this earlier sheet remaining should have its original color, or at least the color which it had just previous to being overridden. Its present color need not necessarily be fresh or untarnished, but there is strong presumptive evidence that no color alteration has occurred since the retreat of the Wisconsin ice which furnished the débris for a protective burial of this older drift.

TOPOGRAPHY OF THE FINGER LAKE REGION

General statement.—The wide, prevailingly mature, lake-bearing valleys of central New York have received critical attention from workers in many lines of geology. Less attention, however, has been given to the more mature defunct valleys generally transverse to these. It is the unusual parallelism of the former, and their marked scenic beauty resulting from the variously interrupted drainage history, that impel the comment of even the untrained observer. These long valleys opening to the north were occupied during the waning stage of the ice-sheet by valley glaciers[1] or by valley lobes which were relatively broad—a condition due to the iceward slope of the valleys.

Topography favors both ice-erosion and ice-stream aggradation.—These conspicuous valleys, digital-like in arrangement, because of their general north-south trend, molded the basal ice of the deploying sheet into forms that expedited erosion. Furthermore, the fact that these valleys sloped toward the overriding wedges of ice facilitated the acquiring of a load which in turn augmented the erosive power of the ice up to the time when the amount of this load became so great that the basal ice lost in velocity; it then did little degradational work. In consequence of this differential erosion we find that approximately the southern thirds of these valleys are zones of ice-aggradation. Therefore Professor Tarr's 900-foot-contour upper limit of most active erosion[2] defines a plain which dips into the Allegheny Plateau. The present attitude of this plain of erosion embodies some post-glacial deformation due to warping; but, neglecting the effects of

[1] H. L. Fairchild, *American Journal of Science*, Vol. VII (1899), pp. 252, 253.

[2] *Popular Science Monthly*, Vol. LXVIII (1906), p. 389.

this warping,[1] it is not likely that the plane would define a surface even parallel to its original attitude. Concerning the relation which this part of our continent bore to sea-level while the Wisconsin ice-sheet was active, we have insufficient data to warrant any but very general conclusions.

It is evident, then, that so far as the north-south valleys are concerned, exposures of the old drift are more apt to be found in a belt skirting the zone of heavy drift in the southern parts of the valleys; northward from this hypothetical belt erosion may have been very active, tending to remove the earlier deposits; southward, aggraded glacial rubbish has probably covered these deposits.

Few of the quite mature transverse valleys belonging to an interrupted but well-developed drainage cycle, above alluded to, have been described.[2] The more nearly transverse to ice-movement such valleys lie, the less ice-erosion they are subject to. Subsequent invasions of ice presumably have not removed much of the residual rock waste that escaped the earliest glaciation; nor would an earlier deposit of drift suffer great erosion. Consequently, valleys of this type are best fitted for the preservation of pre-Wisconsin drift. In the area covered especially by this paper two segments of such valleys, one extending eastward from the vicinity of Branchport (Penn Yan Quadrangle), the other extending westward from Dresden (Ovid and Penn Yan Quadrangles), have been studied.

LOCATION AND DESCRIPTION OF THE PRE-WISCONSIN DRIFT IN QUESTION

First indication of such drift.—In the area from Skaneateles to Keuka Lake the writer has often noted the highly weathered condition of smaller bowlders both on the surface and in cuts in the drift. Later acquaintance with the older drift in Ohio has led him to give further attention to this observation. These scattered, rather rotten crystallines may or may not suggest drift of different ages.

[1] G. K. Gilbert, U. S. Geological Survey, *Eighteenth Annual Report* (1896–97), pp. 603–6; H. L. Fairchild, *Bulletin of the Geological Society of America*, Vol. X (1899), pp. 66–68.

[2] R. S. Tarr, *American Geologist*, Vol. XXXIII (1904), pp. 271–91; F. Carney, *Journal of Geography*, Vol. II (1903), pp. 115–24.

It is not likely that the first or even the second ice-invasion removed all the residual products of preglacial weathering. This much weathered material would constitute a larger part of the first than of any later drift-sheet. And from the fact that residual decay is noted beneath the Wisconsin drift[1] it follows that some preglacial weathered products have withstood several periods of ice-erosion.

Western slope of Bluff Point.—This elongated ridge, drumlin-like in outline and slopes, peninsula-like in reference to the arms of the lake,[2] rises about 715 feet above the level of Keuka Lake. Its longer axis is meridional (Fig. 1.). The striae below the 1,100-foot contour measure S. 65°–28° W. So on the western slope of the bluff the work of the ice was dragging and plucking rather than abrading. But if these striae represent only the final ice-motion in the area, then the work of the glacier may have been more vigorous at an earlier stage. In any case, the striae indicate that this slope was leeward at least part of the time, hence the subdued erosion.

In the veneer of drift we note a conspicuous number of very weathered stones. These constituents in many instances are rotten, going to pieces under a blow of the hammer; others show in cross-section a surface altered zone, one-quarter to one-half inch wide. Even the pitted quartzite bowlders are not rare.

Eastern slope of Bluff Point.—On this opposite slope of the bluff a roadway leading northward from Dunning's Landing makes an exposure of highly weathered material just north of William T. Morris' cottage. This is the only section which suggests a concentration of rather uniformly altered drift constituents; neither the location nor the weathered condition of this exposure necessarily implies old drift.

About one-half mile south of Dunning's a recent stream channel reveals the contact of two distinct types of drift. The upper horizon is the familiar Wisconsin which here overlies a semi-indurated bluish till. This latter is fresh in comparison with the overlying Wisconsin which at this point is about 6 feet thick (Fig. 2.).

[1] H. L. Fairchild, *Bulletin of the Geological Society of America*, Vol. XVI (1905), pp. 64,65; R. S. Tarr, *American Geologist*, Vol. XXXIII (1904), p. 286.

[2] James Hall, "Geology of the Fourth District," *Natural History of New York*, Part IV (1843), p. 159.

Northward along this slope a similar arrangement of drifts was noted in three places.

On these steep slopes heavy rains and spring thaws open new channels cutting 10 feet to 15 feet in a few seasons. The Wisconsin drift is easily channeled; the other resists erosion more effectively. After a few seasons, however, the surface horizon weathers and covers the blue till formerly exposed.

As explained above, the direction of this valley is more nearly accordant with the direction of ice-movement; the older drift here was exposed, therefore, to more vigorous erosion. The portion of this old drift which has survived ice-erosion is the lower, unweathered parts. Thus the old drift is commonly fresher than the new.

The North Crosby exposure.—On the opposite shore of the lake, a few rods up the hill from the North Crosby Landing, a recent stream course discloses a hard bluish till, which shows no evidence of structure, overlain by Wisconsin drift. This channel in places is 15 feet deep; the maximum showing of the basal drift is about 4½ feet where it forms the bed of the cut, but it is not constant, the Wisconsin sometimes forming the entire cross-section of the cut. The hardness of the blue till here is evident from the overhanging of the bowlders (Fig. 3), which may be two-thirds disclosed before dropping from the face of the cut. We have not seen in this material bowlders more than a foot in diameter. The sharp angle of slope which this till maintains in comparison with that of the Wisconsin above is evidence also of the compressive force to which it has been subject.

Mixed exposures.—About a mile southeast of Branchport, near the point where the old valley joins the Branchport arm of the lake, a creek trenches the recent drift, which here contains scattered masses of blue till. We noted one area at the foot of the channel wall which may be in place. The Wisconsin drift here alluded to appears to be from a lateral tongue of ice which fed into the valley, thus disturbing the older deposits.

Another area where old drift is incorporated with the new is at the end of Bluff Point (Fig. 1). Here is a quantity of débris, largely local, dragged around the slope of the bluff.

Keuka Lake Outlet exposure.—The most pronounced section of the bluish till may be seen along the outlet of the lake. A typical expo-

sure is skirted by the highway and is in sight of the New York Central Railroad at Keuka Mills. Here the superjacent Wisconsin is the thinner, measuring a little less than 18 feet, while the bluish till measures nearly 30 feet. The ease with which the former weathers is demonstrated by the low angle of slope, and by the covering of vegetation; the older drift has a steep slope and no vegetation (Fig. 4), and shows very slight evidence of structure.

The outlet of Keuka Lake drops 265 feet in its course of scarcely 7 miles to Seneca Lake; it consists of a rock-bound gorge alternating with amphitheater expansions, in which one or both of the rock walls are absent where the present course crosses or enters a former more mature valley. The older drift is noted particularly in these amphitheaters of the present channel. It is probable, therefore, that the Keuka basin was tributary to the Seneca basin long before the period of bluish-till glaciation.

This same relationship of drifts is noted in the erosion channels of streams tributary to the Keuka Lake Outlet. Along the lateral from the south coming in at Milo Mills, the older drift, where not very coarse, shows a tendency to lamination, the result apparently of excessive pressure. We have noted the same condition in other localities of this region.

The most persistent expression of this bluish drift is found in the Keuka Outlet valley, which is transverse to the direction of ice-movement. The valley is very mature. Naturally the Wisconsin ice-sheet did less corrasive work here than in the arms of Keuka Lake.

Erosion and color.—Furthermore, the line of contact of the two drifts in the exposure about Dunning's and about North Crosby gives a suggestion as to the manner and amount of the erosion. The former contact is about 65 feet above lake-level; the latter, about 90 feet. In east-west cross-section the contact line is a series of sags and swells, or anticlines and synclines, presumably parallel to the direction of ice-progress, indicating its tendency to groove or plow the subjacent surface.

The color of this old drift is strikingly blue in contrast with the adjacent yellowish Wisconsin deposits, and the color persists even in the detached masses that are seen in exposures of the recent drift. It apparently is not the result of post-Wisconsin alteration; the till

has been too much protected for that, and its compactness argues against infiltering waters as the agent. The bluishness covers the bowlders and is constant in the matrix. Evidently the color antedates its erosion and burial by Wisconsin ice.

AGE OF THIS DRIFT

The evidence presented in this paper does not warrant an opinion as to the particular pre-Wisconsin epoch of glaciation with which this drift correlates. Critical study should be given a wider area southward to the outermost moraine of the Wisconsin drift; the numerous exposures noted in the limited territory already examined suggests that other superposed sections nearer the margin may show the older drift in a weathered condition.

The freshness of the subjacent bluish till about Keuka Lake does not suggest its correlation with the highly weathered till in New Jersey described by Salisbury. Nevertheless, this feature does not preclude identity of epochs, since the latter drift, which was never covered by a later till-sheet, has been subject to agents of disintegration during a period that has sufficed for the development of a well-advanced drainage system, the major streams having attained "levels more than 100 feet below the levels of the lowest summits on which the drift occurs."[1]

SUMMARY

This old drift, where now exposed, with one doubtful exception, is fresh in appearance; is very compact in structure, sometimes foliated; its bowlders preserve striae; its upper surface shows erosion, presumably somewhat beyond the removal of the weathered horizon which may be the source of some of the rather rotten crystallines now mingled with the recent drift.[2]

[1] R. D. Salisbury, *loc cit*, p. 759.

[2] The writer has just noted Gilbert's paper, "Bowlder-Pavement at Wilson, N. Y." (this *Journal*, Vol. VI [1898], pp. 771–75). The pertinent feature of this paper is the recognition of the possibility of two till-sheets, and of the certainty of "an epoch of local till-erosion by a glacier. The epoch may be a mere episode interrupting a period of till deposition by the same glacier, or it may be a part of a stage of readvance following a long interglacial period" (p. 774).